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A WEARABLE-BASED SYSTEM TO REDUCE SPACE MOTION SICKNESS BY MULTI-SENSORY PRE-HABITUATION

Abstract

Motion sickness (MS) is a common disturbance occurring in healthy people exposed to specific motion conditions. The most widely accepted hypothesis suggests a sustained conflict between expected and actual sensory inputs as the triggering factor. In space, these mismatches cannot be resolved into a stable self-motion perception as the brain cannot sense gravity. Accordingly, each transition between gravity levels implies space motion sickness for roughly half of trained astronauts, significantly impairing missions and safety for days. Symptoms of motion sickness include vomiting and nausea, but also higher risk of disorientation, visual illusions and sopite syndrome.

Although drugs diminish symptoms (e.g. meclizine, promethazine or scopolamine), they come with unwanted side-effects (sedation, drowsiness) and risks related to intolerances, adaptation and addiction. An alternative to ameliorate MS symptoms are training programs employing centrifuges or rotating chairs that were proven effective in aircraft pilots, but not in astronauts. The key problem is that how self-motion perception adapts to weightlessness is not yet established. Interestingly, astronauts with natural tendency to rely more on an ego-referenced frame (ideotropic vector) than on visual cues have been shown to have less SMS symptoms and a shorter adaptation time.

Pathological visual over-reliance may occur in patients after a transient vestibular insult and become chronic (Persistent postural-perceptual dizziness (PPPD)). A sudden exposure to weightlessness represents the equivalent of a strong vestibular insult: the vestibular sensors for gravity direction abruptly stop working. As for the PPPD patients, developing visual dependence is not uncommon in astronauts and has been related to higher and persistent SMS. Multi-sensory cues to force reweighting of sensorial integration appear overall quite successful for vestibular patients. Although visual dependence and maladaptation are also issues for astronaut, transfer of the know-how from these novel patient rehab in pre-flight habituation has yet to be evaluated.

The main aim is to develop a pre-rehabilitation lessening space motion sickness (SMS) by simultaneous manipulation of different sensory cues to create sensory conflict conditions that can be resolved when the subject adopts our desired reference frame. In practice, as astronauts with natural tendency to adopt an ego-referenced frame have been shown to suffer less SMS and adapt faster, the pre-rehabilitation should reinforce this reference frame against a visual-based one. A training paradigm successfully achieving this adapted state will have a double advantage: it will prevent overreliance on visual cues and promote a rapid switch to this learned strategy when gravity cues are absent.